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ABSTRACT

This paper presents the history of environmental education with regard to major issues, theories, and goals; environmental education in science education curriculum; and inquiry-based approaches. An example for environmental education curriculum content and an example inquiry laboratory for environmental education are included. (KHR)

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ENVIRONMENTAL EDUCATION: NEW ERA FOR SCIENCE EDUCATION

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1) Introduction:

History of Environmental Education

Although environmental education seems quite a new area for education arena, its roots have been coming from the 18th century. Many writers, philosophers such as Goethe, Rousseau, Haeckel, Froebel, Dewey, and Montessori had very significant influence on the transformation of environmental education in the way it is being perceived today (Palmer, 1998). Although the terms *"environment" and "education"* has not been seen together until the mid-1960s, many different names have been used instead of this environmental education such as *rural studies, environmental studies* etc. In 1948, the term *"environmental education"* (EE) was used as the first time in the International Union for the Conservation of Nature and Natural Resources in Paris. Finally, in 1970, classical definition of environmental education was formulated:

> Environmental education is the process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the inter-relatedness among man, his culture, and his biophysical surroundings. Environmental education also entails, practice in decision-making and self-formulation of a code of behavior about issues concerning environmental quality (IUCN, 1970).

The concrete steps for environmental education were taken in the 1970s which is one of them was in Paris Convention. Gradually, in 1972, Stockholm Conference addressed the importance of environmental concern in education. In 1975, it was during

the Belgrade Conference when the organizations that affiliated environmental concern including NGOs were gathered. The last milestone in the 1970s was Tbilisi Conference in U.S.S.R that established concrete goals and the frame for environmental education. In the 1980s, the propagation of environmental issues has been pointed out over and over again. Unfortunately, the new wage in political arena ignored the importance of environmental education. For instance, legislations about environment were quite disappointing because of reluctant approach about environmental issues. On the other side, NGOs especially Greenpeace International has protested against this approach that present and previous governments held all over the world. The last, indeed, most important conference of this century was held in 1992, in Rio de Janeiro called **"The Earth Summit"**. The pros and cons of this conference reflected different perspectives. The perceptions on environmental protection or awareness of the governments and NGOs were different. Still there is not a common agreement or a consensus on environmental issues and many concepts.

2) What is still being discussed regarding environmental education?

Major Issues, Theories, and Goals

As mentioned above, many issues are still debatable in this area, some of which are; the borders of concept of environmental education, what should be taught, whose values will be dominant, what kind of classes science educators need to take at undergraduate level to handle it, how environmental education can be integrated into traditional curriculum and which perspectives should be held such as **ecocentric**, **technocentric** approaches (O'Riordan, 1988), what types of research models are the most

functional for the progress in environmental education such as **positivist** (Hungerford et al., 1980), **interpretivist (constructivist)** (Schwandt, 1994) or critical paradigms.

Given the facts, environmental concern and education have different facets including politics, mass publics, elite groups, and scientists, educators with their moral and political values, which can sometimes function as barriers. Obviously, multidimensional structure of environmental concern has a strong influence on EE in different ways.

One of the most important topics in environmental education is **subject-matter**. In the last 30 decades, the earth has faced many environmental problems. Some of them can be listed in order: population growth, poverty, and inequality. Depending on aforementioned issues, some subject matters needs a more global attention such as food and agriculture, tropical forests, biological diversity, desertification and drought, fresh water, oceans and coasts, atmosphere and climate, management solid waste and sewage, hazardous substance, epidemic diseases (such as AIDS), and the last but, not the least, available potential energy and its share equally in the world as much as possible for more environmental friendly production (Palmer, 1998; TWWI, 2001), including social paradigms and dimensions .

Secondly, some terms such as **sustainable development** and **sustainable growth** are still controversial both in the academic arena and politics. So far, anyone defined these terms, specifically *sustainable development*, as one liked it. Some of them have tried to give priority to economy in this concept; while others emphasized moral values instead (Barbier, 1989). Briefly, sustainable development is a term that is supported by *ecocentrists*. On the other hand, sustainable growth is a term that has been embraced by

mainly *technocentrists* including business/financial environment. Ideologically, ecocentrists believe in *"the redistribution of power towards decentralized"* (O'Riordan, 1988). But honestly at this point, there is not a common ground for the **decentralization of power**. Many governments all over the world have been talking about sharing the power with local governments however; willingness of the power sharing depends on the perception of democracy in society, the history of democracy, traditions, the patterns of economic system, and finally but the most importantly, the willingness of present political power to keep it or share.

Consequently, it is not easy to create and maintain authentic environmental curriculum without any government and business/finance manager's pressure. Even if the principles, goals, and objectives of environmental education change depending on ideological perspective, fortunately during Tbilisi Conference at1977 authorities agreed upon underlined common goals of environmental education. These are as follows:

1) To foster clear awareness of, and concern about, economic, social, political and ecological inter-dependence in urban and rural areas.

2) To provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment.

3) To create new patterns of behavior of individuals, groups and society as a whole towards the environment (UNESCO, 1978).

Although the goals of EE sound quite fascinating and humanistic, this is not enough to convince mass population to comprehend the vital role of EE for future generations.

3) Why Environmental Education and How Does It Fit in the Science Education Curriculum?

As implied before, the ultimate goal of EE is to create more environmentally concerned generation in the world. In many regards, EE serves a unique opportunity to the students to melt all science branches in a pot, to **motivate** *inquiry and brainstorming cooperatively*, to **discuss** *social consequences in democratic atmosphere*, and to **reach** *the best acceptable solution* **using** *mathematics, physics, biology, geology, chemistry*, and *social sciences* critically.

Contemporary books and guidelines about science education address the importance of **inquiry-based** approach (p. 134, AAAS, 1989; NCR, 1996; Henry, 1960). Meanwhile many concepts such as *creative thinking, critical thinking, problem-solving abilities, authentic problems, performance assessment, the role of both student and teachers in class, brainstorming, multidisciplinary class,* and *professional development* are some of the major topics in new education approach.

From this point of view, EE is a quite compatible with contemporary learning theories such as constructivism and aforementioned terms to reach out acceptable goals of EE such as *economic productivity of society, thinking critically, solving problems creatively, working cooperatively in teams as a group member, using in real life, using technology effectively* (depending on different EE perspective) (NCR, 1996). From the same spectrum, different assessment styles will naturally match the spirit of EE such as self-assessment, portfolio. As emphasized by authorities over and over again, professional development (PD) will be an unavoidable component of present and future science teachers due to progressive and multidisciplinary nature of EE. However, we

need to bear in mind that, we should have a redesigned approach for preparation of pre-service science teachers at undergraduate level is what we need to care about desperately as science teachers and academics.

How Concepts of Contemporary Theory Find Application in EE:

INQUIRY –BASED ENVIRONMENTAL EDUCATION

3a) Use authentic problems: (FAT questions, Divergent questions)

Unless presented with authentic/real-world problems, students might not get engaged in science easily. Some well-known environmental problems both locally and globally habitat might be helpful to be comprehended by students. These environmental issues need to be presented at a level that is suitable for them, it is in this way that they will be able to realize the importance of being globally and locally oriented citizens and comprehend that they can build up their own self-esteem to deal with real life problems by integration with their own pure and social science backgrounds.

3b) Use multidisciplinary face of science:

Environmental science class encourages both teachers and students to bring together different science branches such as botanic, zoology, geology, physics, mathematics, soil sciences, and social sciences and help analyze, synthesize, and evaluate their background knowledge themselves. In short, environmental science course does not have a lateral dissolution; in the contrary it motivates all participants in class to be active partners. Thus, environmental science class is a big opportunity for students to create/solve (get involved in) authentic problems in their real life experiences and teacher to engage in their professional development.

3c) Motivate curiosity for creative thinking:

The nature of science is based on curiosity. As long as teachers do not capture students' interest, students will not be engaged in the learning process and this will not be easy to detect. That is the reason teachers should allow students to take their time to think creatively with open-ended process and class/group discussion.

3d) Support being a critical/skeptical thinker:

Driving questions (WH), rather than *yes/no questions*, are the most important part of pushing students towards being critical thinkers as mentioned by Bono (Andersen, 2001).

3e) Enhance problem-solving abilities with collaborative work and Authenticity:

There is not one absolute/correct problem solving strategy. However, more acceptable approach is to use variety and encourage students to solve problems in their own ways. Obviously, this approach leads students to be more creative and answer with their own judgments.

3f) Define roles for both teacher and student:

The new role of the teacher in class is being a **facilitator**. The student's role can be defined as an **investigator** and an **inquirer**. To some extent, these definitions can clarify and put an exact place the new roles in class; but still there is a concrete gap between practical application and theoretical approximation of these terms. Particularly, the definition of facilitator should be misunderstood because being teacher does not merely comprise being facilitator. If we ignore the historical and vital role of teachers in class, we both inhibit the **professional development** of teacher intensely and unconsciously and create many paradoxes regarding to the fundamentals of contemporary

science education. Contrary to general science courses, environmental science course does not allow both the teachers and the students to have one defined role because of its multidisciplinary characteristics. I should stress that these definitions for roles in class might create a paradox in science educators. To eliminate this discrepancy, or misunderstanding, it should be made clear that a facilitator is a **motivator**, an **organizer** and **feedback giver.**

3g) Encourage teachers getting involved their own professional development:

As mentioned above, the definition of teachers' role should be clarified since their own responsibility in class will most likely affect their ongoing careers and intellectual levels. As stressed before, because of the multidimensional characteristics of environmental sciences course, science teachers and the students should be more interested in their own area even if they are not willing to get involved in.

3h) Disseminate findings/conclusions:

It is clear that dissemination of findings is the last and one of the most important steps of fruitful hard work. Students should have enough self-esteem to present their research results by use of both technological equipment and traditional methods.

3i) Find and Use appropriate performance assessment materials for both teachers and students (Self and collaborative assessment):

Assessment process is a debatable issue for teachers, students, as well as other people in concern. It is very value-laden and subjective; even if which hold in hand as an assessment is the best, it is always problematic. Variety in assessment process is an appropriate solution. Instead of chosen just one assessment style, a combination of

alternative assessment methods should be used such as self, collaborative and peer assessment.

All items mentioned above will help and encourage science educators to have a new perspective named an **"inquiry-based approach in environmental education"**, even if there is no perfect concrete recipe for a state-of-art environmental education. Hopefully, the mentioned concepts might help science teachers achieve their goals in their environmental courses in a comfort.

4) What does EE promise us? Are we ready for EE?

First, we always need to take into account that the gap between practice and theory in EE, as well as in different branches of education, has always been an important issue and possibly will exist forever. In fact, many school curricula are **disciplined** and **theoretical-based**. This is what we call **the traditional school program (TSP)**. The alternative approach is **action-oriented school program (AOSP)** that embraces an **interdisciplinary** and **flexible inquiry** approach (more opportunity for students to explore and reinvestigate their own ways) in schools. The last model embraces a more holistic approach, cooperative learning, and active thinkers in schools. But is this transition from the TSP to the AOSP easy? Are we ready to handle with upcoming problems as science educators and as students?

Absolutely, it is difficult to say that we are all ready for environmental education. Before the transformation process, course revision should be held and considered again at all undergraduate level science courses that are for the science educator candidates.

Second, science teachers should be qualified as environmental scientist that is why teachers who are interested in giving environmental course should be assessed with

different holistic instrument that can measure their intellectual, creative, and conceptual knowledge capacity.

Third, because of its multidisciplinary dimension, we should differentiate environmental courses from other science courses such as earth science, mathematic, physics.

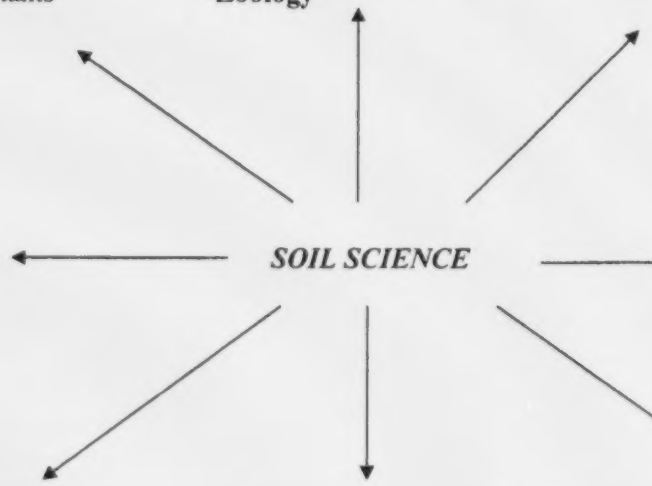
5) An Example for EE Curriculum Content

THE INTERCONNECTION OF ENVIRONMENTAL EDUCATION WITH OTHER SCIENCE BRACHES

Ecological Cycles
-Biodegradation
-Bioaccumulation
-Acid deposition
-Organic and inorganic pollutants
-Nutrient Cycles

Soil Biology
-Microbial activity and interaction
-Microorganisms
-Adaptation and habitat
-Zoology

Botany
-Active and passive transportation
-Mineral uptake
-Contact dislocation and carbonic acid theories



Geology
-Rock formation
-Rock deformation
-Weathering
-Paleontology
-Soil Genesis
-Evolution

Social Sciences
- Social consequences and dynamics

Environmental Protection
-The protection of habitats
-Natural resources
-Energy consuming

Soil and Water Chemistry
-Redox potential
-Oxidation-reduction
-pH change

Soil Physics
-Capillary action
-Adhesion- cohesion
-Electro negativity
-Negative pressure, diffision-osmosis

6) An Example Inquiry Laboratory for Environmental Education

The Effects of Temperature on Biodegradation (in different soil textures)

Objective: The student should hypothesize which factors might influence biodegradation process. The students should know how to design experiment to test hypothesis, collect and interpret data (particularly student will be encouraged to use Window-Based programs such as Excel in order to collect and store the data), and disseminate the research findings (Using PowerPoint will be expected presentation style). This inquiry laboratory also will highlight the relationships between different science branches such as organic chemistry, biology, geology, soil sciences, instructional techniques, and mathematics.

Prerequisite Concepts: Conceptual knowledge about the terms such as biodegradation, mineralization, decomposing, fundamental definitions about microorganisms, organic and inorganic material.

Question Style: Question sequences will be based on as defined by Jos Eltsgeest (Andersen, 2001). Questions are designed as stated by Guilford with the exception of *cognitive-memory* questions. *Convergent, divergent,* and *evaluative questions* are posed to students. Problem posing questions can be defined as *FAT questions* or divergent questions which could be answered in different ways. The main goal is to show that *there is not only one answer is the main strategy to be comprehended by students.* This inquiry laboratory is based on Piaget's *"point-at-ability"* phrase (Andersen, 2001).

Laboratory Type: Laboratory application will be conducted by using the *Open Inquiry Style.* Students' active participation is a fundamental principle of this inquiry-based

laboratory. The teacher's role can be defined as facilitator, questioner, and active motivator.

Questions before Inquiry Laboratory: What do you think with regard to decomposition of organic materials in different situations? What kind of physical, chemical and biological factors can affect the biodegradation process of organic material? What data will you collect? How will you input your data? What kind of experimental design will you use to conduct your research? How will you display your data? How will you display the differences between two organic materials regarding biodegradation ratio noticeably? (Using histograms with EXCEL is acceptable).

Materials:

- ✓ Different organic residues such as peanut and apple residues
- ✓ Plastic container (250ml)
- ✓ Three different soil types (organic soil (peat, muck, bog etc.), dominantly clay, and dominantly sand)
- ✓ Freezer
- ✓ Scale

Lesson Scenario:

Preparation

- ✓ Choose two different organic material residues (each of them is 5 gr/dry weight)
- ✓ Choose three different types of soil (100 gr/dry weight)
- ✓ Choose two different temperature levels (4°C and room temperature)
- ✓ Place plastic containers after filling different kinds of soils and residues into freezer and in an appropriate place in the room

- ✓ Pour 10mlt water all containers
- ✓ Prediction (Hypotheses) with group members
- ✓ Observation and data collection during two weeks (Table 1. Data collection sheet attached to page 17)
- ✓ Discussion with group members
- ✓ Evaluation with group members
- ✓ Conclusion with group members
- ✓ Disseminate (present) the findings with group members

Questions after Inquiry Laboratory: (Eltsgeest, 1985)

- ✓ Can you see any difference between peanut and apple residues as regards reduction of their weights? (Attention)
- ✓ How have weights of the residues changed through the experiment? (Through the biodegradation process) (Measure)
- ✓ Can you compare weight change of organic residues in different soil types? (Comparison)
- ✓ What did you observe in different temperature? (Action)
- ✓ What do you think biodegradation process of other organic materials? For instance crude oil? (Problem posing)
- ✓ Why and how do their biodegradation processes vary? (How and why question)

Other Alternative Questions:

- ✓ What were your predictions before the laboratory? Did it change?
- ✓ What do you think regarding which factor (variable) has relatively more impact on biodegradation process?

- ✓ Which soil type could better incorporate the biodegradation process? Why?
- ✓ Which organic material is the most degradable? Why is one of them more degradable than the other one?
- ✓ How do these factors such as temperature level, soil type, water content etc. have direct or indirect effects on biodegradation?
- ✓ What and why do you think that these different situations can cause to change the metabolic activities of microorganisms in the environment?

Self-Assessment:

The aim of this assessment is to help both students and teacher verify some pros and cons of foregoing science class. This assessment will not take a time in class period (a short paper). This assessment will be based on self-assessment regarding what they have learnt throughout the process.

Table 1: Residue weights changes depending on soil type, temperature, and organic material during 2 weeks

	Clay				Organic soil				Sand			
	1D	3D	7D	14D	1D	3D	7D	14D	1D	3D	7D	14D
Apple Residue (gr) 4° C												
Apple Residue (gr) 25° C												
Peanut Residue (gr) 4° C												
Peanut Residue (gr) 25° C												

Invitation to Inquiry (Divergent or FAT Question)

Performance Objectives: The student should state environmental problems and use appropriate technology and mathematics to pose alternative solutions to these problems. The student should inquire about the function of physical, living, or designed systems. The student should know how to manipulate environmental variables for unexpected situations. The student should know how to apply computer-based programs to anticipate the impacts of hazardous materials on the environment (by using EXCEL spreadsheet). The student should use concept map in order to make connections between related ecological issues and terms. The student should study collaboratively and share their thoughts eagerly.

Definition of Problem:

- ✓ Location: 63.5 km^2 lake where 174 bird species nest.
- ✓ The lake has one input and one output point.
- ✓ This natural lake had been used each spring and summer as an irrigation reservoir to irrigate farmlands since 1990. It was decided by the former Secretary of Agriculture to shut down the output point during the spring and the summer. However, The EPA opposed this decision.
- ✓ Since 1965, city waste has been directly discharged into the lake. Disposal materials consisted of organic residues (aromatics, aliphatic, biocides, etc.) and heavy (toxic) metals.

Question: In the late 1990s, coniferous forests started to die around the lake. Furthermore some sensitive fish species have been seen rarely. What are your assumptions about the future of the lake, coniferous forests, animals (particularly birds

and amphibians) and farmlands? How can you state the problem (according to the attached map page 20)?

Question: Can you see any differences among the different regions regarding toxic metal concentration and organic material accumulation?

Question: What do you assume in this situation regarding the biological diversity of the lake? In what way?

Question: What do you think regarding B.O.D? Will it go down? (B.O.D might be difficult concept for students even for college students. Thus, science teacher should encourage the students to comprehend this term).

Question: If the input and output of the lake are opened again, what kinds of scenario can you draw regarding the eutrophication process?

Question: Can you make predictions in terms of physical, chemical, and biological properties of the lake?

Question: What can you predict about biodiversity around the lake for the near future?

Question: According to data given below, can you make a prediction for this lake for next 10 years? 1,000 m^3 of organic material flows into the lake in a year. Twelve and a half percent (12.5 %) of all materials can be oxidized within a year. The other residues accumulate on the benthic zone. If the volume of the lake is 1,000,000 m^3, when will this lake be unavailable for irrigation because of over sedimentation (Use EXCEL spreadsheet)?

If you are environmental protectors, what can you do in order to maintain biological diversity in this lake?

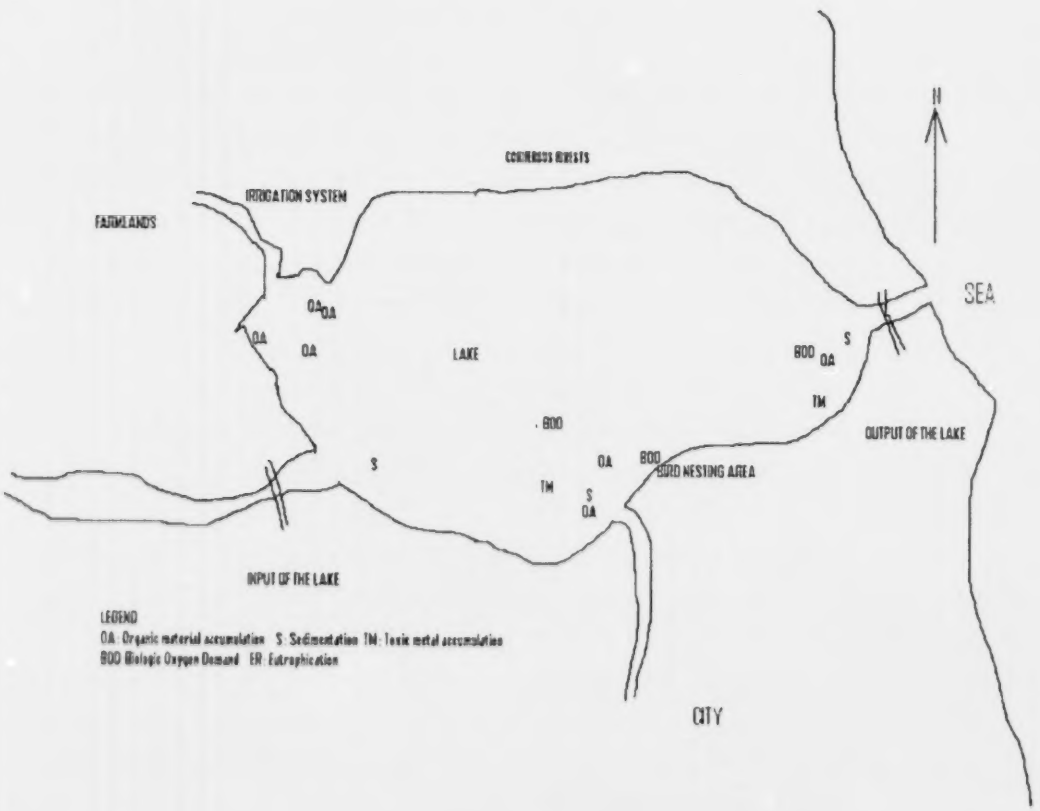
If you are *technocentric* or *ecocentric environmentalist* as a consultant for farmers, what can you suggest them to decrease pollution in lake (Learn and discuss these terms).

Stages

- ✓ Problem definition
- ✓ Prediction-Manipulation
- ✓ Evaluation
- ✓ Conclusion
- ✓ Presentation
- ✓ Discussion

→ Collaborative Work

Map 1: Inquiry scenario



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